Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

VARIETIES OF TIDES.

BY

ALEXANDER BROWNLIE.

THE RED SEA VARIETY.

In the consideration of our subject thus far, the frequent failure of flood-tide forms the distinctive feature in each case, but in the case of the Red Sea it is not so. At Aden, the standard port for reference for the Red Sea, the prevailing type is semi-diurnal; but there are a number of days throughout the year in which only one high water occurs, and an occasional day in which there are none. This variety also differs from all the others in respect to its environment, for it is furnished with only one line of communication with the ocean, the Strait Bab-el-Mandeb. This strait is 13½ miles wide, but in it lies Perim Island; the wider channel is 10 miles wide, and the sounding line shows that it is close upon 200 fathoms in depth.

Through this deep but comparatively small channel all the power is transmitted which operates tide in a sea fully 1,200 miles long by 200 in the widest part. At Perim Island the mean rise is 5 feet 3, and the highest waters range fully 2 feet higher. At Suakin (in the widest region) the mean is only 1 foot 3, and extremely uncertain tides both in time-intervals and height of rise prevail all through the wide region; but in the Gulf of Suez, at Suez, they range from 4 to 7 feet. This gulf has a length of 170 miles, with an average width of 30.

So the Red Sea possesses a very large region of small tides in the centre and small regions of comparatively high tides at either end. Although the opening at Perim is so small, yet the tidal energy is so great after passing the centre that floods are forced up as high at Suez as at the opening. This fact seems to be accounted for by the straight course of the sea, in which there is no barrier to deflect and weaken the direct force of the pressure; but it is not so with the Gulf of Akabah, for that gulf is not only barred at the entrance, but it lies at a considerable angle off the line of pressure; hence in it the floods are fully 2 feet lower than at Suez.

At Aden the time-intervals range as wide apart as 9 hours to 16

---

* Concluded from BULLETIN No. 5, 1902.

from one high water to another. According to the forecasts for this port, the rise at times is as high, and even higher, at the quarters than at the new moon or full. For example:

DATE.	PHASES OF MOON.	PREDICTED RISE OF TIDE.
Jan., 1900....	Full..................	6 feet 5
“ “ ...	1st Quarter...........	6 “ 7
June, “	3d Quarter...........	6 “ 7
“ “	New..................	6 “ 7
July, “	Full..................	6 “ 8
“ “	3d Quarter...........	6 “ 9
“ “	New..................	6 “ 4
Aug., “	3d Quarter...........	6 “ 6
“ “ ...	New..................	6 “ 6
Dec., “	New..................	6 “ 8
“ “	1st Quarter...........	6 “ 8

According to the science of the tides, if the moon can raise the floods at Aden 6 feet in height at new moon or full, then at the quarters it ought to raise them 2 feet only; and according to the U. S. Tables for 1902 for Aden in January, February, June, August, September, and December tides are predicted to rise as high as at new moon or full from five to nine days *before* or *after* new moon or full. Now, this is also contrary to the fundamental laws of the lunar science.

With regard to that most striking feature in all variation—days in which flood-tide fails to rise—Mr. Darwin says:* The Royal Engineers made a series of predictions for Aden covering some two months, then they followed that up by an observation of their forecasts, which resulted in the discovery that one predicted flood failed to appear.

The forecast being made and recorded, of course there was no failure there.

The failure lay with the sea itself; it did not rise at the time the engineers predicted that it would rise.

Possibly this occasional failure may throw a new light upon a very old subject—the celebrated historical incident connected with the escape of Israel from the bondage of Egypt; for it is quite within the range not only of the possible but of the actual that the freaks of this variety were known by the leader of Israel, for he had spent forty years of his life in Egypt and forty years in the desert over against Egypt.

---

* The Tides, p. 245.

Was he not learned in all the wisdom of the Egyptians? The historian of the times tells us that the march at first was not directed in a bee-line to the desert of Sinai, but along the border of the sea, and on the Egyptian side of it, into what seemed a natural trap, where, seemingly, it would be easy work to capture them, when, lo! at the dread moment, when capture was nigh, one of the floods failed to appear, and with the opportune moment came the order to change the march from south to *east*. It was a night march. But did Israel march dry-shod across the sea? Nay, across a dry shoal, which the Egyptians also essayed to do, when, lo! a six or seven foot flood came rolling along, and, in the words of the ancient war song, celebrating the victory,

> They sank in the depths like a stone. *

The historian also gives the important information that at the time of crossing

> A strong east wind blew all night and made the dry land. †

In our own times it is even now a matter of fact that the height of floods at Suez is frequently controlled by the wind, and the greatest difficulty to modern navigation arises from the prevailing northeast wind.

It is also a matter of observation that floods flow from the sea into the canal for about seven hours, while ebbs flow out for about five. The modern harbours, also (some two miles south of Suez), are separated from that town by "a shoal which is dry at low water." ‡

At an early period in the history of the Red Sea the Gulf of Suez penetrated farther north than at present. The evidence is quite clear that it once covered a series of depressed shallow vales, whose surface was coated with a deposit of salt, which had all the appearance of a covering of snow.

That was previous to the opening of the canal; but by the opening of the canal these former salt vales have been transformed into salt lakes, the largest of which, the Bitter Lakes, extend some twenty-three miles in length.

Such an extension of narrow sea provides a reason for the march *south*—of Israel—at the start, and it also provides a natural way, a shoal at ebb tide, to make good their escape; but in unison with these was the natural agent expressly named by the historian:

---

* Exodus XV.

† Exodus XIV, 21.

‡ Encyclopædia Britannica, Vol. XXII, page 620.

> A strong east wind made the dry land, and the waters were divided.

That is, the shoal divided the waters of the lakes from those of the gulf.

DOUBLE TIDES IN THE ENGLISH CHANNEL.

This variety of double tides has long been the subject of scientific speculation in France and Great Britain. With regard to it, Lord Kelvin said *:

> In Portland Harbour, sometimes, the water rises, sinks, seems to think about it, and then rises again. This harbour has a double low water. Southampton has a double high water, and the double high water seems to extend across the Channel, for there is a double high water at Havre Bar. At Southampton the water remains high three hours, then dips a little. It then rises for one and one half to two hours before falling to low water.

The cause of these remarkable tides was no less a riddle to the distinguished lecturer than to his distinguished hearers, for some observers had said that the Isle of Wight was the cause, while others found it in the Strait of Dover. But it was the opinion of the lecturer that the small Isle of Wight could not cause the remarkable disturbances both at Southampton and Havre; and in this reasonable conclusion we agree.

In order to make a reasonable explanation of all the freaks of this variety, we ought to discover the cause in the larger geographical environment of the whole Channel itself, for the smallness of area in the two places named is altogether insufficient to account for the greatness of area affected by the disturbances. The eastern end of the Channel is suddenly contracted from a width of about seventy miles to one of twenty in the Strait of Dover, but between Southampton and Havre the width greatly exceeds seventy miles. Now, the comparatively insignificant area at Dover is absolutely insufficient to account for the disturbances at Southampton and Havre. On the other hand, at the time of flood-tide, in the eastern end of the Channel, the smallness of the Strait is also absolutely insufficient to relieve the pressure; consequently only a small portion of that flood finds an outlet through the Strait, and the great bulk of it flows back to whence it came in the succeeding ebb. And, by the pressure of that returning ebb, we find the solution for some of the details of the problem, but only some, because the balance is explained by the fact that a large area of the eastern end is co-tidal, and we call it the English Channel basin.

---

* Lecture to the British Association at Southampton, 1882.

On the French side of the eastern end flood-tide continues to press onward for about one and one half hours after Havre is supplied, so the co-tidal basin continues to receive that pressure for that length of time after the level has ceased to rise on the English side.

When the ebb from the basin sets westerly, it takes about one and one half hours to return to Havre Bar; consequently that return pressure causes a second rise on the bar. But the second rise is also partly due to the environment of the peninsula west of Havre, for it bars the way of the receding ebb. So this explains the riddle of the double tides at Havre Bar.

Upon the English side the Channel basin remains at the condition of high-water level for the remarkably long period of three hours, and that basin extends from about Southampton to the neighbourhood of Dover. The long duration of high water in the basin is partly explained by the longer duration of supply on the French side; and on that side, be it observed, the supply is also much greater in bulk. For instance:

FRENCH SIDE.	MEAN RISE.	ENGLISH SIDE.	MEAN RISE.
Havre	17 feet 3	Southampton	9 feet 9
St. Valery en Caux	20 " 6	Portsmouth	10 " 2
St. Valery sur Somme	22 " 0	Newhaven	15 " 3
Boulogne	19 " 4	Hastings	18 " 3
Calais	16 " 2	Dover	15 " 2

Observe that the rise at the St. Valerys is double that at Southampton, and at Havre it is also considerably higher than that at Portsmouth. The long duration of flood at high-water level in the Channel basin is due not only to the continuous pressure at the French side, but also to the fact that east of the Strait of Dover, in the North Sea, the English Channel flood-tide encounters the pressure of the North Sea flood. The two pressures block and balance one another, and thus form the English Channel basin by keeping it at high level for the long space of three hours; but at the expiry of the three hours the "little dip" of Lord Kelvin occurs, because the pressure of flood in the co-tidal basin is then relaxed, and from its higher level above the level at Portsmouth and Southampton the ebb from the basin in its passage westward has the effect of a second flood, because *it flows from a higher level to a lower.* So in its passage by Southampton it causes a second rise there; but when the passage is effected, then occurs the fall to low-water level, and that explains the riddle so far as Southampton is concerned. By the time the ebb arrives at Portland harbour it is the time of first low water there, and the pressure is still sufficiently strong to keep local sea-level steady for a while; but when that pressure is relaxed, then the water falls to the second low level. And that explains his Lordship's riddle in full; and, so far as we know, for the first time.

The principle of geographical environment, whether applied to small seas or great, ought to give a reasonable explanation of all tidal variation; whereas "the power of mathematics," the specific solvent of lunar science, "fails totally in the attempt to express the transmission of tide waves." * "The irregular distribution of land and water and the variable depth of the ocean produce an irregularity in the oscillations of the sea of such complexity that the rigorous solution of the problem is beyond the power of analysis." † Now, why should mathematical analysis be considered the only method to be used in finding out a problem in geography?

Men usually unravel such problems by *sight*, and not by mathematics! Nobody finds that the oceanic currents are due to the influence of the moon. Why, then, should the action of the tides be considered due to the action of the moon? The answer is, because a wrong method was applied to solve the problem at the first, and that wrong method was begun when no man knew aught of the tides of the world! They also, at first, used a wrong method of looking at the movements of the air. Not so long ago all men believed that changes in the weather were caused by the changes of the moon. There existed a lunar weather science down to about the middle of the nineteenth century. We have since turned from that kind of moon-weather science; and it is merely a question of time when the geographical principle will be accepted as the only right principle to solve every tidal problem instead of the moon-tide solvent, mathematics—an absolutely impotent solvent, and acknowledged to be such by Mr. Darwin himself. ‡

In this article we have already called attention to the fact that even the North Pacific Ocean is only one of the varieties. Still more evidence in proof of that remarkable fact is furnished by M. Elisée Reclus. In one of his books he cites the failure of expected flood-tides, which never appeared at all at Petropaulovski.** And in that ocean we have also showed that high and low water take place on the same meridian! ††

---

* Sir Geo. Airy, Johnson's Cyclopædia, Vol. IV, p. 1699, 1st edition.

† Prof. Geo. H. Darwin, Encyclopædia Britannica, Vol. XXIII, p. 355.

‡ The Tides, p. 188.

** New Physical Geography, Vol. 2, page 93.

†† April, 1902, Bulletin Am. Geographical Society, N. Y.

Now, according to the lunar science, neither the failure of floods nor the meridian high and low water ought to be possible in the Pacific Ocean. But the fact of their occurrence in the very ocean where tides are supposed "to be most normal," and to respond more accurately and quickly to the supposed "pull" of attraction, is the impregnable proof of the absolute failure of that science.

And no wonder, for the modern masters of that science—Whewell, Airy, and Darwin—based it upon "an almost total ignorance" of the tidal conditions of the Pacific Ocean.* Nevertheless, Airy and Whewell removed the seat of lunar attraction from the equator—where it had been placed by the old masters—to the South Pacific Ocean. So, then, the new departure instituted by them is not based upon evidence, but upon an admitted ignorance of the actual tidal conditions at the "cradle of the tides"—the "cradle" from whence globe-travelling waves are supposed to supply flood-tide to all the earth!

---

* The Tides, p. 189.